Characterization of Land Surface Emissivity in AMSR Channels from Combined AMSR-E, AIRS and MODIS Measurements

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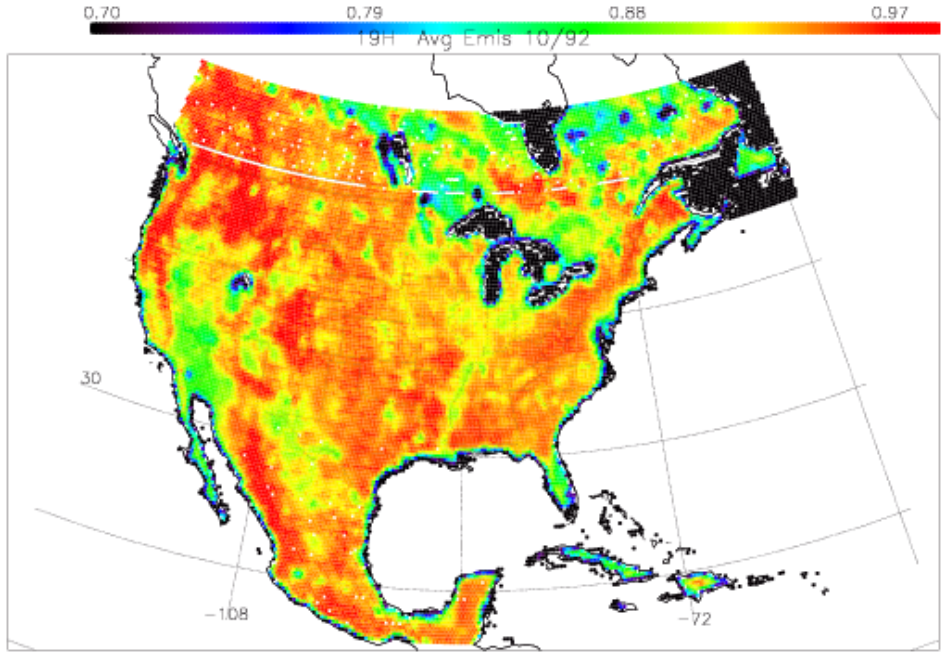
Introduction (1)

- Goal: derive high temporal resolution global AMSR emissivity database with sufficiently ***high accuracy*** for enabling useful retrieval of LST, cloud liquid water and water vapor over land from AMSR measurements
- Builds on previous work from C. Prigent on SSM/I and AMSU



Monthly average 19H SSM/I emissivity for the month of October 1992 (Prigent)

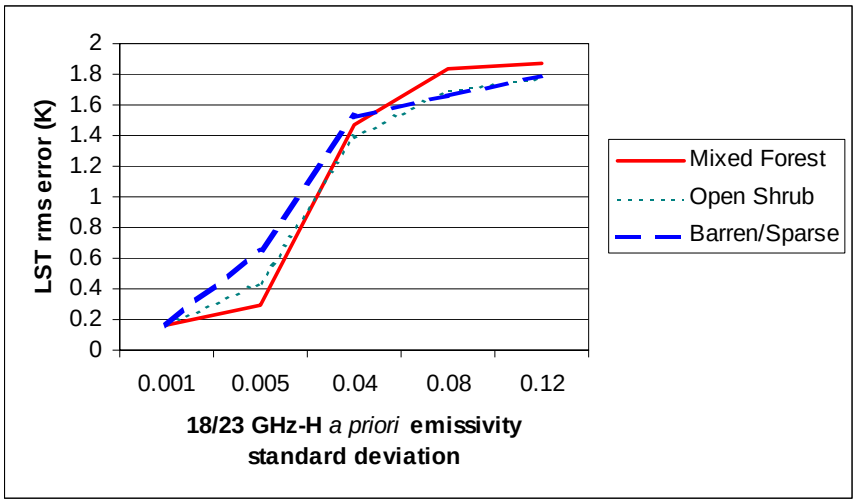
Introduction (2)

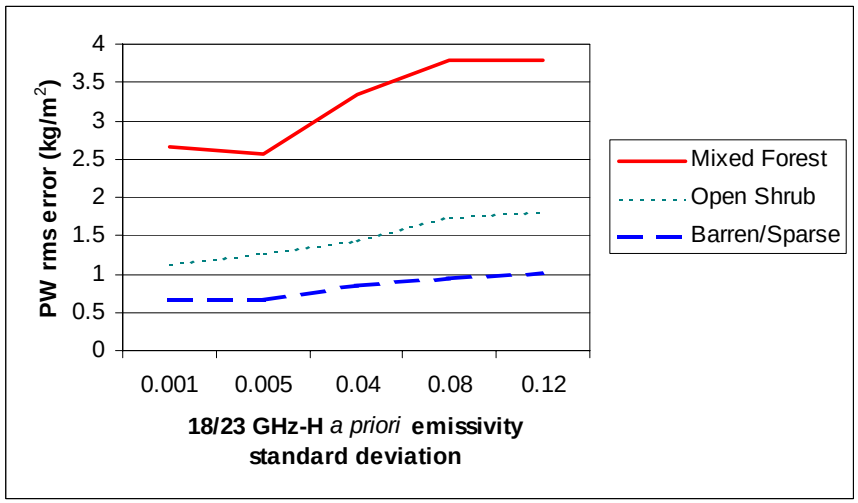
- Use matched measurements from combined AMSR, AMSU/AIRS and MODIS to help specify atmospheric and surface state (LST, surface type) in AMSR field-of-view
- Take advantage of the high information content of EOS/MODIS imager and AMSU/AIRS sounders as well as unique temporal/spatial co-location between those measurements to improve quality of emissivity product
- Produce LST retrieval for the time period considered

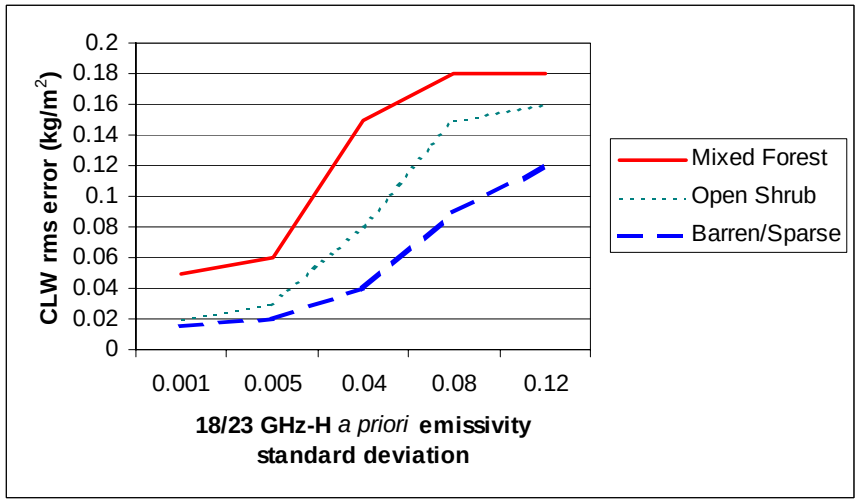
Potential applications of gridded surface emissivity product

Science Area	Parameters	Comment
Global surface property characterization		
Microwave land retrieval support/ assimilation in meteorological models	Precipitation, LST, CLW, PW, Snow Fraction	For all these applications, good *a priori* spectral surface emissivity information is critical; database is universal and can serve many other conically-scanning microwave sensors, thereby providing high local refresh
Sudden event and retrieval quality control	Floods, Snow, RFI, Precipitation	The UR and emissivity database will provide a natural means of detection through large Chi-squared residuals, lack of convergence, and sudden changes in retrieved emissivity

Microwave land retrieval performance as a function of a priori knowledge of surface emissivity (cloudy conditions)







Land Surface Emissivity Database

- Static data base of seasonally or monthly average emissivities is sufficient in areas with little inter-annual variability and in well established vegetation regimes
- Usefulness of static data base is limited during transitional events, regions of large inter-annual variability (e.g., mid-latitude winter) and in instances of precipitation events (e.g., flood)
- Optimal results obtained with dynamically updated local emissivity database
- Accurate first guess requires tracking local emissivity changes and dynamically updating emissivity database
- Dynamic update can be performed by time averaging retrieved emissivities

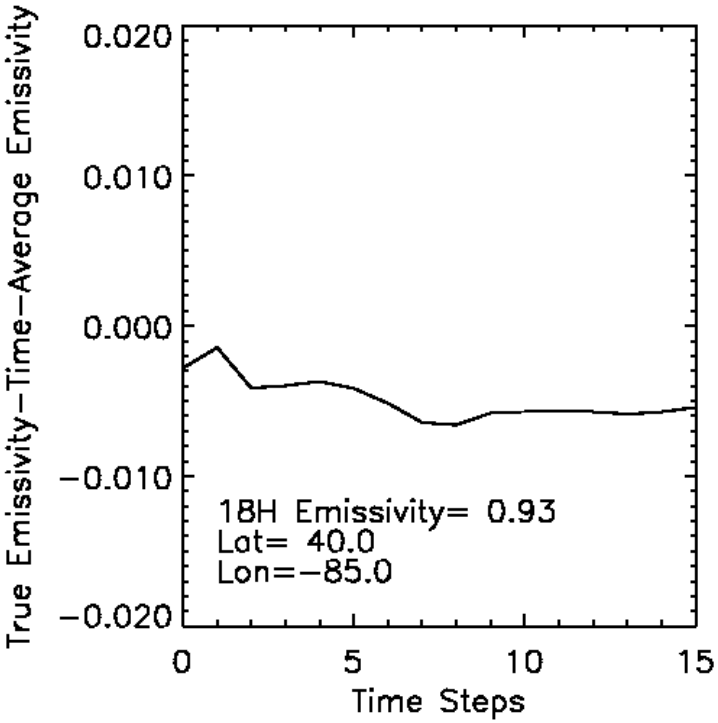
Plans

- Process one full year of global land data
- Produce AMSR emissivities (may include AIRS as well) and LST database on fixed resolution Earth grid
  - 25 km resolution (Nyquist sampled) for frequencies > 18 GHz
  - 50 km resolution (Nyquist sampled) for 10 GHz channels (TBR)
  - 75 km resolution (Nyquist sampled) for 6 GHz channels (TBR)
- MODIS sinusoidal grid selected
- Long term plans is to make such processing part of the NPOESS/CMIS operational algorithm which would ensure routine generation of such product for the lifetime of the NPOESS program

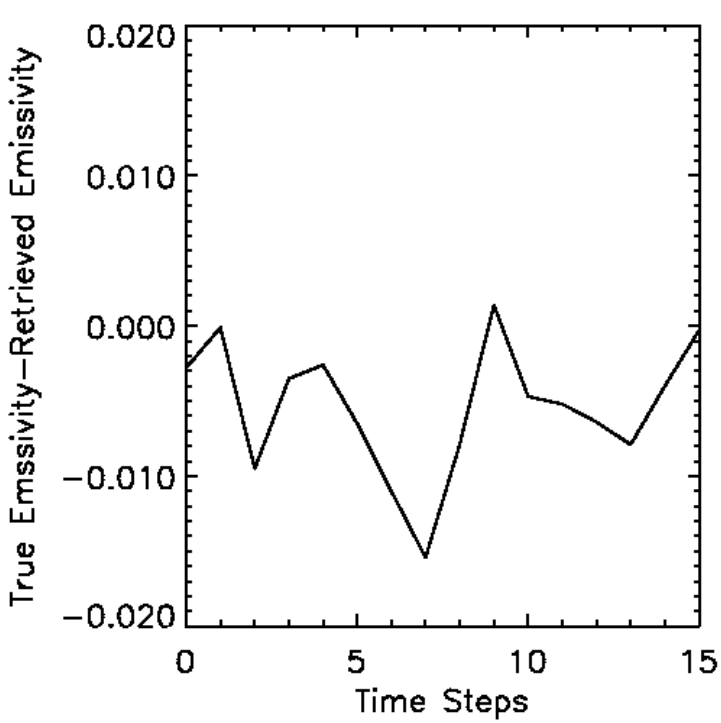
Approach (1)

- Emissivity estimation scheme uses existing non-linear (maximum-likelihood based) physical retrieval algorithm:
  - AIRS atmospheric product (atmospheric temperature and water vapor profiles) and MODIS LST provided as background to the inversion
  - Retrieval approach provide the ability to make adjustments to PW, CLW or LST over background, if necessary (e.g. in partly cloudy or cloudy conditions)
  - In cloudy situations, can use local knowledge of surface emissivity (obtained in the clear sky) to also constrain surface emissivity estimation
  - Comparison between modeled and measured AMSR radiances provides mechanism for detecting changes in surface properties when time persistence is used

Example of application of time persistence to SSM/I retrieval (simulation in stand alone mode)



Time constrained 19H emissivity retrieval



Instantaneous 19H emissivity retrieval

Approach (2)

- (1) Clear sky (based on MODIS cloud detection): high quality AIRS/MODIS data product available:
  - First step is to populate data cube to include emissivities obtained in clear conditions
  - Product of this step can be used to derived inter-channel constraint for surface emissivity (by region or surface type) used in subsequent estimation process
- (2) Partly cloudy:
  - degraded AIRS/MODIS performance
- (3) Mostly cloudy/overcast:
  - based on temporal persistence of emissivity

Assumptions

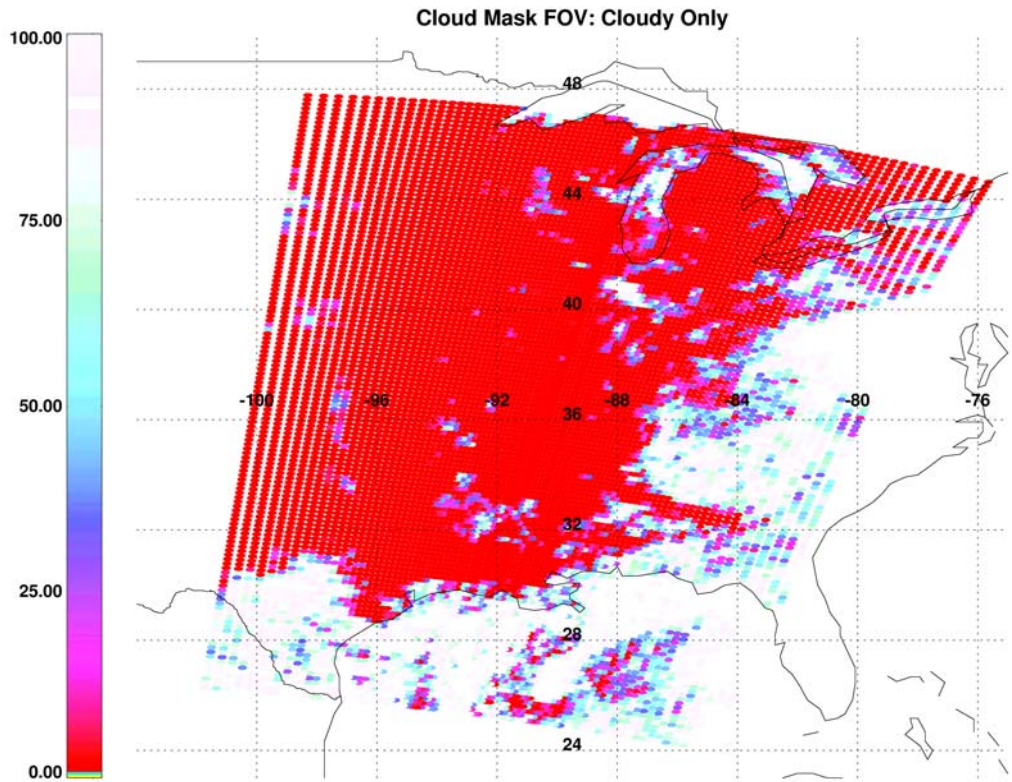
- Specular reflection assumed
- Neglect frequency dependent penetration depth (most important over dry desert surfaces)
- LST may need adjustment to account for systematic differences between IR and MW information

Summary of Error Sources in Microwave Emissivity Estimation

Error sources	Treatment	Comments
Errors in profiles of temperature and moisture from AMSU/AIRS	Included in the simulations	
Microwave radiometric noise	Included in the simulations	
Residual clouds	Mitigated as part of trade of between frequency of observations and tolerated error	Impact is expected to be small at low frequencies and higher at 89GHz H
Errors in cross-sensor LST (from e.g. MODIS)	Systematic errors included in the present budget margins; random component included in simulations	
Geolocation and horizontal re-gridding errors	Will be budgeted - most important over inhomogeneous terrains (e.g. near coast lines and water bodies)	These regions will be flagged using high resolution surface type database
Change of azimuth over high slope variance terrain	Not corrected – present data will be used to study those effects	These regions will be flagged using topography database
Radio-frequency interference (RFI)	Not corrected - most important at 6 GHz	One of the application of the database is the detection and monitoring of intermittent sources of RFI
Radiative transfer model calibration	Not included in the present budget	Prior to applying the system we will perform a simple co-calibration of AMSR with AIRS over oceanic background – this calibration can be refined at a later stage

Quality Control (1)

- MODIS cloud mask used to identify condition of cloudiness in both AIRS and AMSR footprints
  - Complement AIRS Level 2 QC flags based on AIRS information only
  - Select method used to extract AMSR surface emissivity
  - MODIS mask independently validated using SERCAA algorithm; option to switch to SERCAA if necessary

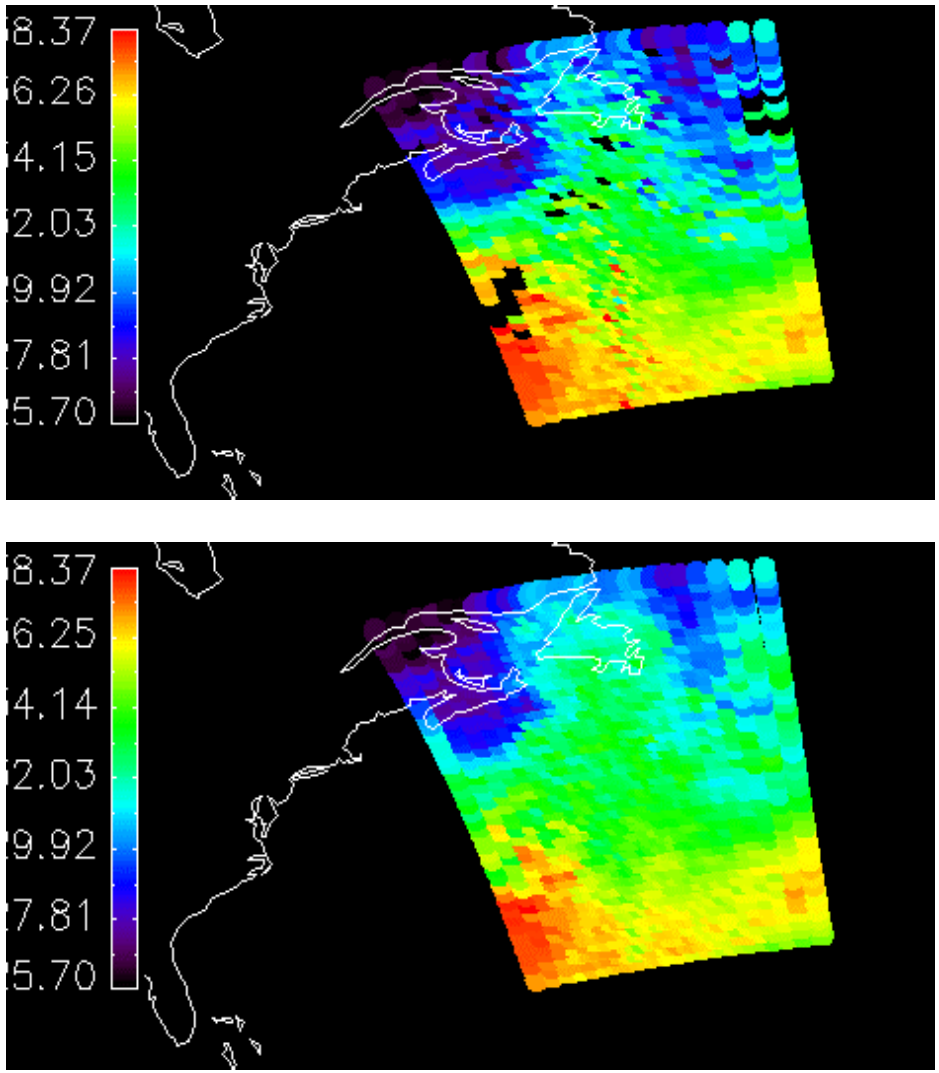


Quality Control (2)

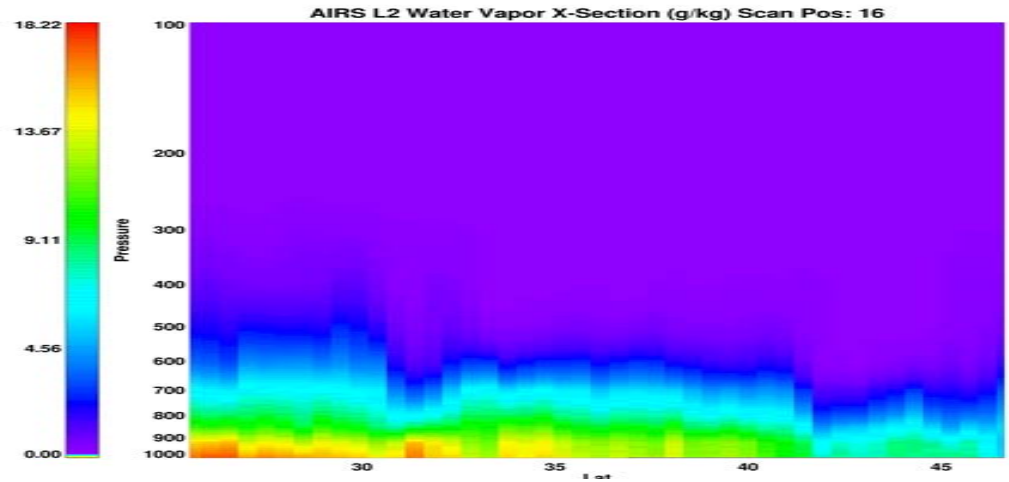
- AIRS retrieval product depends on success of cloud clearing process
- Performance below cloud top degrades to that of AMSU alone in overcast conditions
  - AMSU/AIRS product verified against NCEP analysis and RAOBS over land
  - AIRS LST compared to MODIS LST
  - Performance correlated with existing auxiliary information e.g. surface type and cloud information from MODIS and topography
- Existing recursive filter may be used to fill up spatial gaps in real-time quality controlled AIRS product
- Option to replace AMSU/AIRS retrieval with global NCEP analysis if necessary

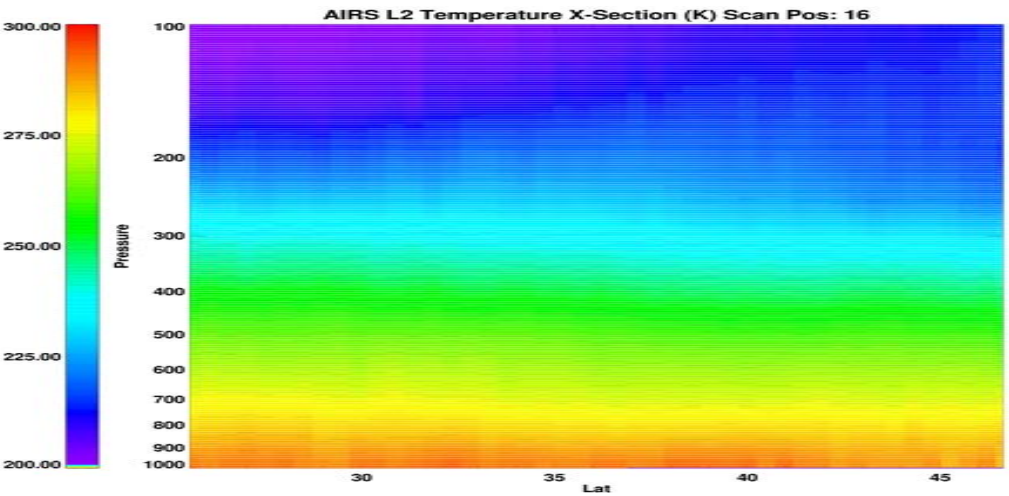
Application of Recursive Filter to AIRS Data

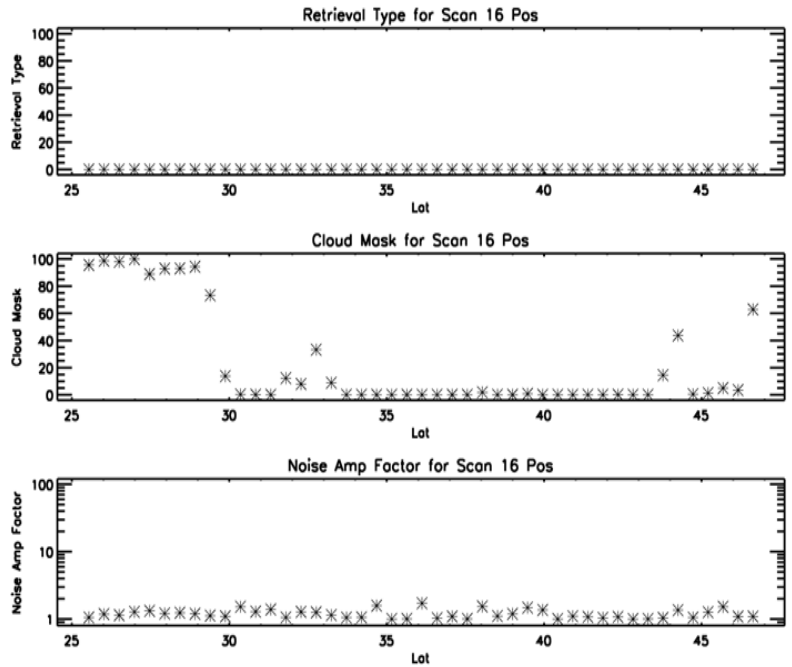
- Upper panel shows the slant path temperature field at 100 mbar (note regions of missing data). Lower panel shows the field interpolated to the local vertical positions from the slant reports (the range is 225 to 238 K).



AIRS Temperature and Water Vapor Profile QC







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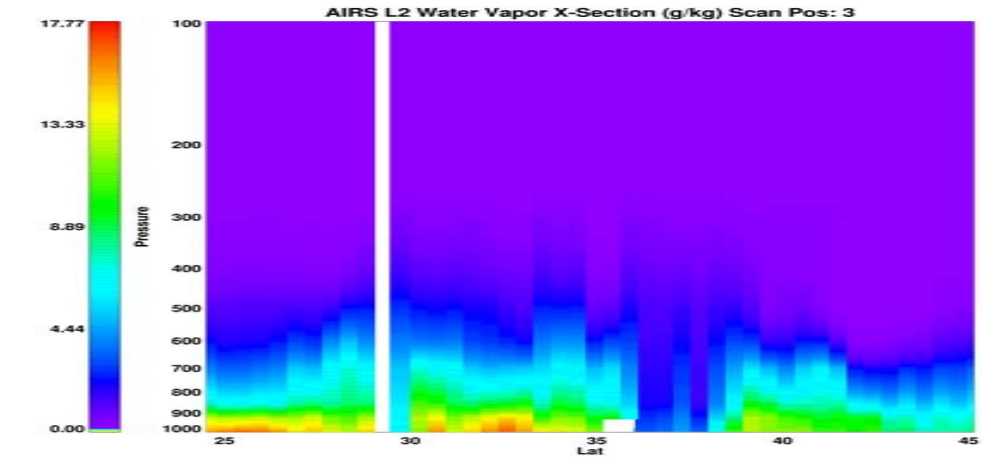
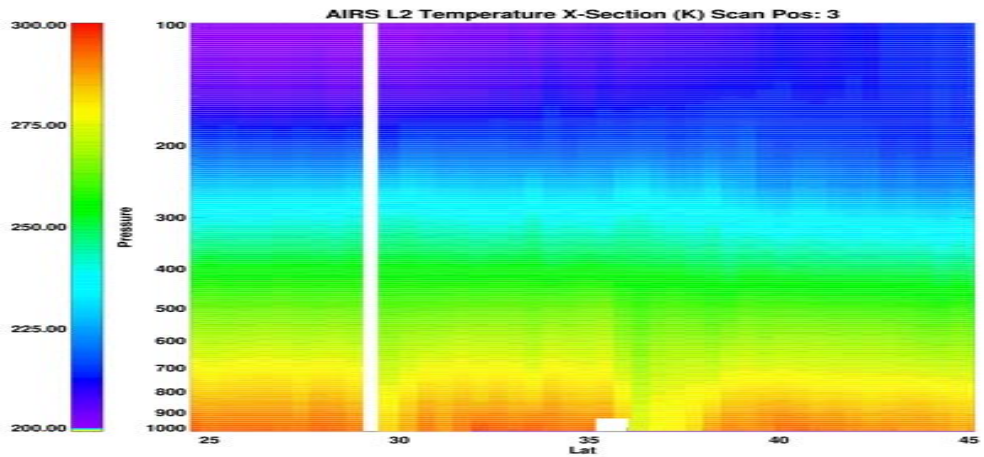
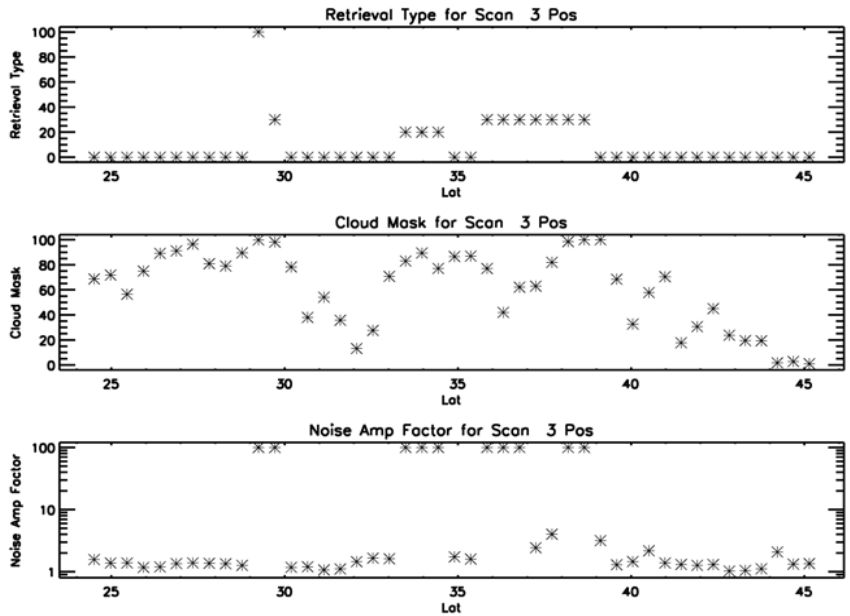
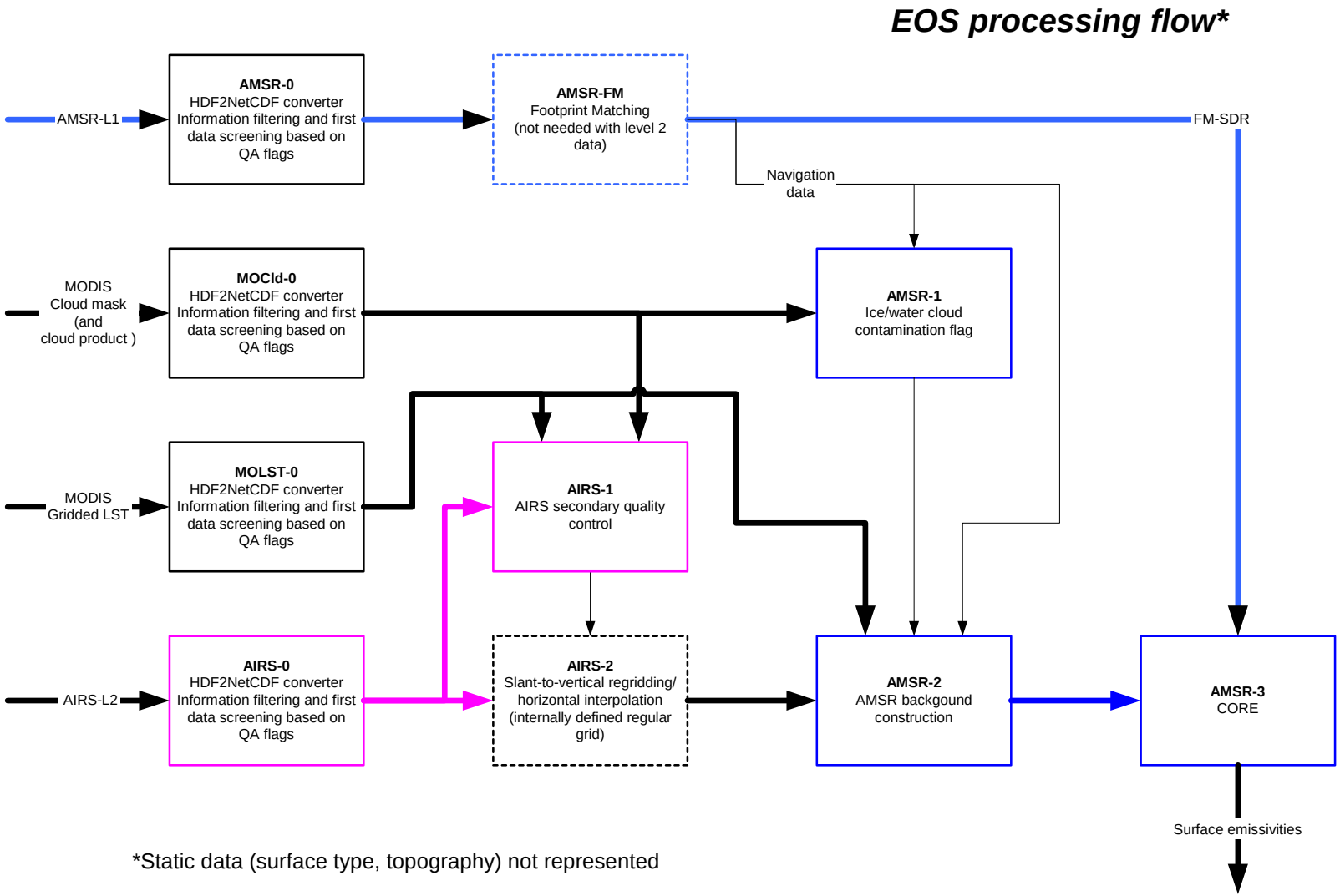






High level flow diagram of AMSR emissivity retrieval process



*Static data (surface type, topography) not represented

Validation

- Direct validation of surface emissivity is notoriously difficult out side of qualitative correlation of product with vegetation/surface type, precipitation events,…etc.
- Indirect validation will be investigated:
  - Cloud liquid water detection capability highly sensitive to accuracy of a-priori surface emissivity information:
    - Could estimate uncertainty in product by comparing retrieved cloud liquid water field to MODIS cloud mask
  - LST retrieval against conventional measurements (and MODIS in clear areas)
- Direct observations
  - ARM CART site
  - Oklahoma Mesonet
  - SMEX03 (airborne C and X-Band, field measurements)